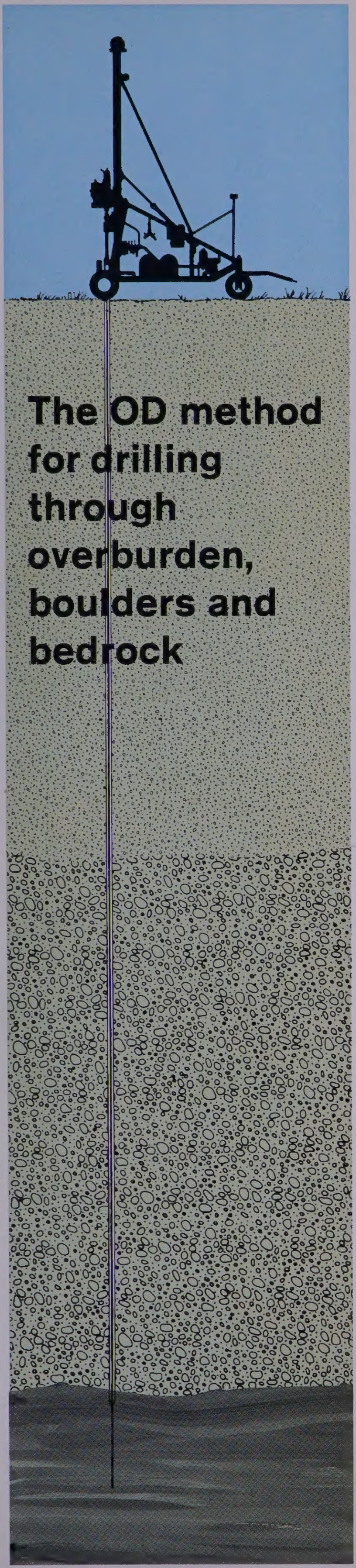
The OD method

Atlas Copco

BOREAL INSTITUTE
LIBRARY
FEB 9 1971

Pam: 622.233
ATL

POLAR
PAM
4291
POLARPAM



The OD method for drilling through overburden, boulders and bedrock

The Overburden Drilling Method has made drilling possible in cases where it was, for technical and economical reasons, not previously feasible and offers significant improvement in a wide range of drilling problems.

The method was originally introduced to solve an excavation problem which arose during the building of a canal for ocean-going vessels on the east coast of Sweden.

This led to the method being named after its most significant feature – that of making it possible to drill through all kinds of geological stratum – and down to, and through, bedrock.

It thus makes it possible to carry out penetration, blasting, grouting, etc., without removing the overburden.

This leaflet illustrates the versatility of the Overburden Drilling equipment by suggesting various applications, and gives examples of projects successfully performed by means of the Overburden Drilling method.

CONTENTS

2 The OD method in brief.
3 Equipment for OD drilling
5 Specification of drill unit
6 Underwater blasting
9 Blasting bedrock under overburden
10 Anchoring
12 Grouting
14 Blasting trenches
14 Alluvial mining
15 Subsoil and mineral exploration
16 Locating bedrock, testing rock quality
16 Drilling through rock fill

00327

The OD method in brief

Double drill equipment

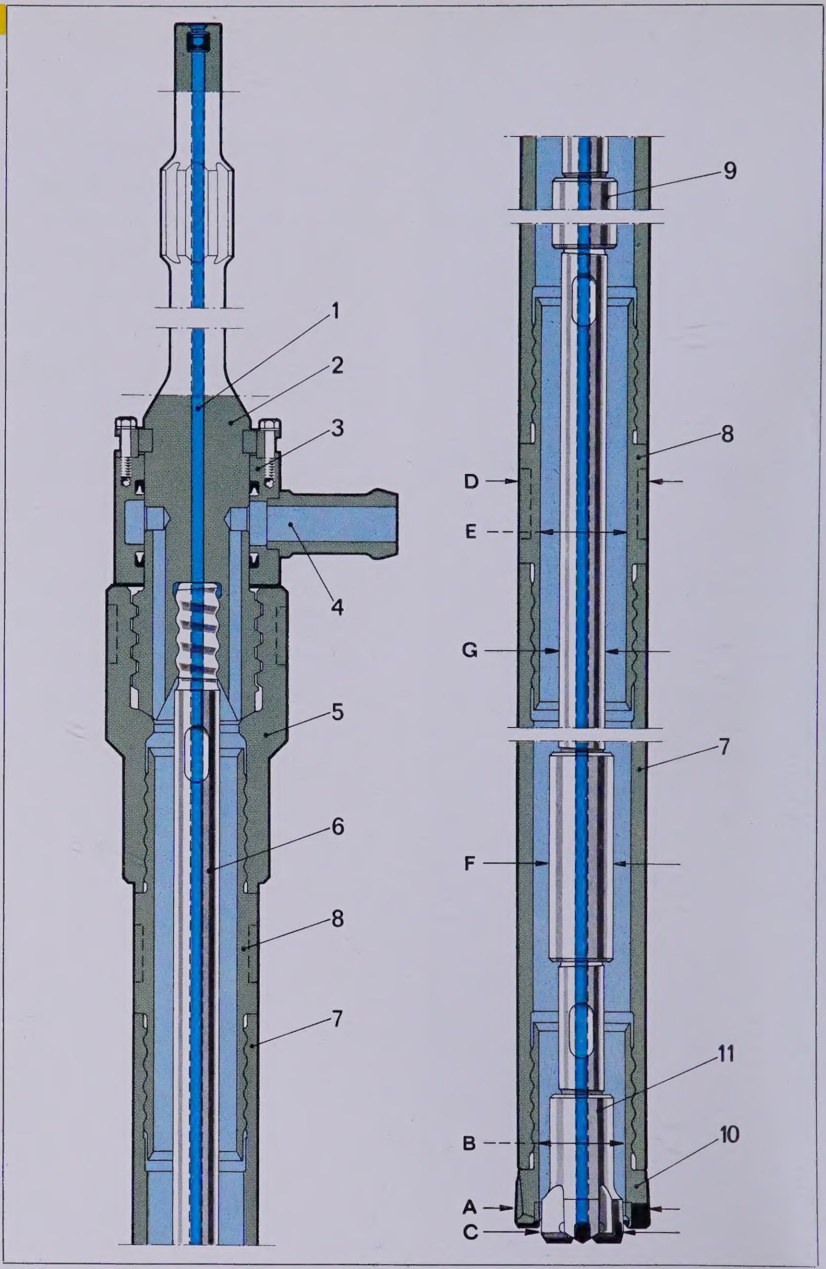
Using a combination of percussion, rotation and high-pressure water flushing, a drill rod and an outer tube are enabled to penetrate the overburden together.
The outer tube carries a ring bit, and the drill rod a cross bit; both bits are tipped with tungsten carbide. The cross bit stands proud of the ring bit, acting as a pilot. As drilling proceeds, extensions are added to the rods and tubes by means of coupling sleeves.

Independent control

of percussion, rotation, feed rate and flushing allows the driller to select the right combination for easy penetration of **any** type of overburden. The drilling action can be changed instantly, as soon as the bits hit a new formation.
If drilling is to be continued after reaching bedrock the drilling equipment is first allowed to collar a few inches into the bedrock. The remainder of the hole is drilled by the cross bit and drill rods alone. It is, of course, also possible to drill in rock with the tube and ring bit.

Open all the way

When full depth has been reached, the rods are withdrawn, the tubes being left as a casing in the overburden section of the hole. The result is an unobstructed hole – from surface to bottom, however loose and unstable the surrounding earth strata – through which various kinds of equipment may be introduced to carry out a great variety of operations.

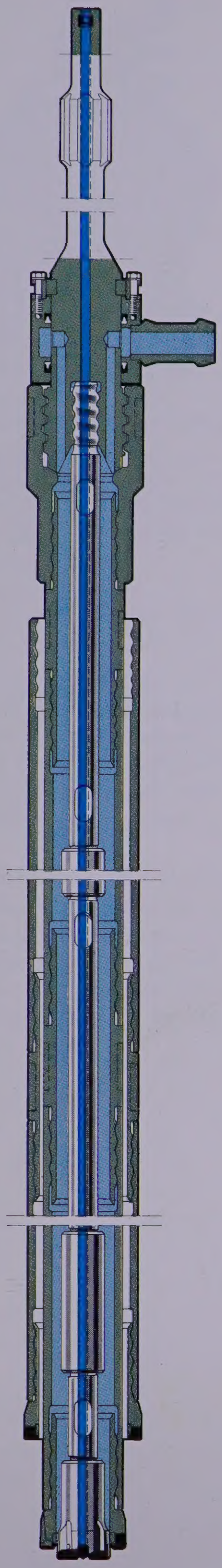


Principal parts of the OD equipment

1. Hole for central flushing
2. Shank adapter
3. Head for separate flushing
4. Hole for separate flushing
5. Adapter sleeve
6. Drill rod
7. Drill tube
8. Coupling sleeve for drill tubes
9. Coupling sleeve for drill rods
10. Ring bit
11. Cross bit

Some dimensions

OD equipment size			2 3/4 in.		3 1/2 in.		5 in.	
			mm	in.	mm	in.	mm	in.
Ring bit	outer Ø	A	88, 92	3 15/32, 3 5/8	107	4 7/32	153	6
	inner Ø	B	56	2 3/16	73	2 7/8	109	4 9/32
Cross bit	outer Ø	C	51	2	70	2 3/4	102	4
Coupling sleeve for drill tubes	outer Ø	D	86	3 3/8	103	4 1/16	141	5 9/16
	inner Ø	E	–	–	72.5	2 27/32	109	4 9/32
Coupling sleeve for drill rods	outer Ø	F	43	1 11/16	55	2 5/32	55	2 5/32
Drill rods	outer Ø	G	32	1 1/4	38	1 1/2	38	1 1/2



Equipment for OD drilling

Diameters

There are three standard sizes of OD drilling equipment — 2 $^3/_4$ in. with external coupling sleeves and 3 $^1/_2$ in. and 5 in. with internal coupling sleeves. The 2 $^3/_4$ in. and 3 $^1/_2$ in. pipes can be carried as drills inside the 5 in. pipe.
A special leaflet describing standard Sandvik Coromant drill steel equipment in detail is available on request from your nearest Atlas Copco representative.

Depths

The reach of the drilling equipment varies to a very large extent depending upon the nature of the overburden. The following figures are therefore approximate.
The usual reaches are:
2 $^3/_4$ in. equipment 60 m (200 ft)
3 $^1/_2$ in. equipment 50 m (165 ft)
5 in. equipment 25 m (80 ft).
Telescopic drilling with 2 $^3/_4$ in. equipment inside the 5 in. pipe thus allows a maximum combined reach of 75 m (250 ft).
The 3 $^1/_2$ in. equipment inside the 5 in. pipe can drill to a depth of 65 m (215 ft).

The telescopic drilling method

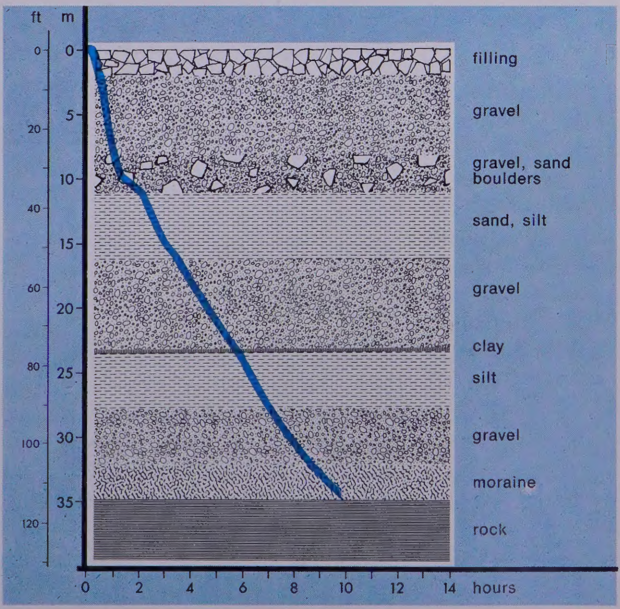
Drilling is carried out in two steps. The 5 in. OD equipment is used for drilling down to its optimum depth, after which the inner equipment is replaced by 3 $^1/_2$ in. or 2 $^3/_4$ in. OD equipment and drilling is resumed down to the full depth.

Standard drill unit

A standard OD unit consists of a percussion rock drill incorporating independently controlled power rotation, mounted along with a chain feed on a rubber-tyred drill wagon. The entire unit is powered by compressed air.

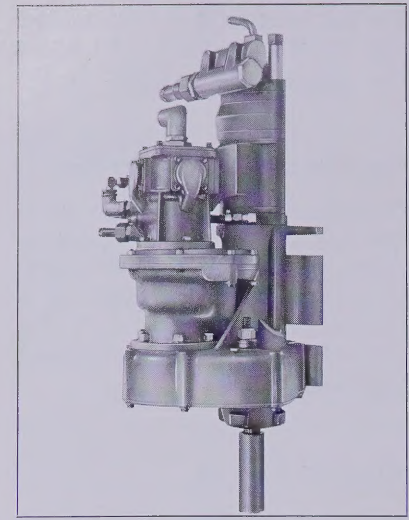
Special units

OD drilling can also be carried out with other suitable rigs. For example, when drilling from rough ground it is often necessary to have a crawler-mounted unit, such as the Atlas Copco ROC 601. Moreover, the rock drill is easily mounted on special rigs, trucks, tractors, rafts, etc., if required. For large-scale jobs, it has frequently proved beneficial to build special drill towers for handling complete strings of pipes and rods.

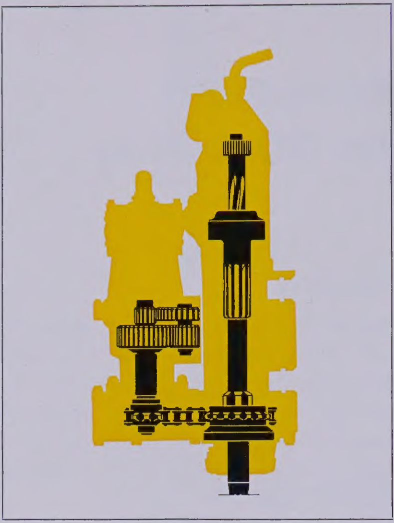


Drilling rate

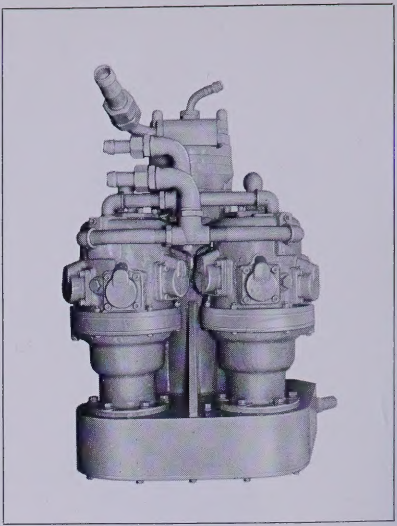
No definite capacity performance figures can be given for any machine drilling in overburden. However, the diagram gives an idea of possible drilling rate.



Rock drill type BBE 57-01, with the separate rotation motor to the left. This motor develops 4.5 hp at 2750 rpm and a torque on the drill string of 80 kpm (580 ft/lb).



Working principle of the rock drill. The rotation motor transmits torque to the shank adapter via chain-and-sprocket reduction gearing.



Heavy-duty rock drill type BBE 53 equipped with double rotation motors giving 6 hp at 1000 rpm and a torque on the drill string of 120 kpm (870 ft/lb).

Rock drill

The impact and rotation mechanisms operate as independent units, though both act on the same shank adaptor. All the piston energy is used for percussion.

A separate piston-type air motor powers the rotation mechanism. Rotational torque is transmitted to the shank adaptor by reduction gearing. The speed of rotation is infinitely variable from zero up to 50 rpm, and the direction of rotation can also be instantly reversed. There are two sizes of OD rock drills – medium-duty BBE 57-01 and BBE 53.

Shank adapter

The percussive impact and rotation developed by the rock drill are transmitted to the drill rod and drill tube by a shank adapter. The adapter has an internal rope thread to take extension rods and an outside trapezoidal thread for an adapter sleeve, which in turn has an internal rope thread to take extension tubes.

Flushing

Water flushing is by a central tube running from the rock drill backhead through the piston to the shank adapter. This tube admits enough water for most drilling jobs. However, when drilling deep holes in difficult ground it may be necessary to increase the water volume. This is done by mounting a separate flushing head on the shank adapter. Air flushing can of course also be used.

Chain feed

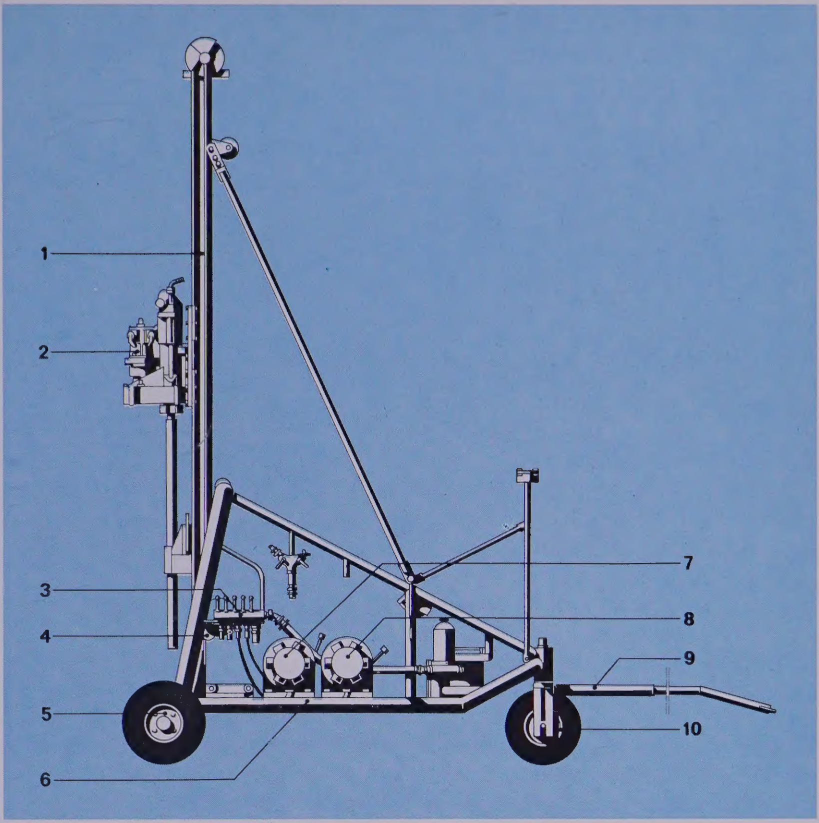
The rock drill is attached to the cradle of the chain feed beam. The chain feed is driven by a four-cylinder air motor, which is instantly reversible to provide rapid withdrawal. Swivelling of the feed beam makes it possible to drill inclined holes. A guide at the lower end of the beam stabilizes the drill tubes and rods. The feed takes 15 ft 9 in. (4800 mm) lengths of extension tubes and rods.

Drill wagon

The chain feed is mounted on a three-wheeled, rubbertyred wagon, type BVB 33, of tubular steel construction. The two 5 1/2 in. × 10 in. front wheels can be swung through 90° to permit either longitudinal or transverse movement over the drilling area. The pivoting 6 in. × 9 in. rear wheel is provided with a drawbar.

Two compressed-air-powered winches facilitate hoisting of drill tubes and rods. The hoisting cables pass over pulleys mounted on the feed beam.

A central lubricator provides oil for all compressed-air components mounted on the drill wagon. All controls for the rock drill, feed mechanism and winches are conveniently mounted on the drill wagon.



A standard OD unit mounted on drill wagon BVB 33

1. Chain feed beam
2. Power rotated rock drill
3. Control panel
4. Feed motor
5. Front wheels
6. Drill wagon
7. Winch for extracting drill tubes
8. Winch for extracting drill rods
9. Drawbar
10. Rear wheel

SPECIFICATIONS

Rock drills

Type	BBE 57-01		BBE 53	
Cylinder bore	120 mm	4.72 in.	120 mm	4.72 in.
Piston stroke	66 mm	2.60 in.	65 mm	2.56 in.
Blows per minute at 6 kg/cm^2 (85 psig)	1950		2200	
Rotation motor output	4.5 hp at 2750 rpm		6 hp at 1000 rpm	
Drill string rotation	60 rpm		50 rpm	
Torque on drill string	max. 80 kpm	580 ft/lb	max. 120 kpm	870 ft/lb
Length	900 mm	35.4 in.	875 mm	34.4 in.
Weight	170 kg	375 lb	250 kg	550 lb

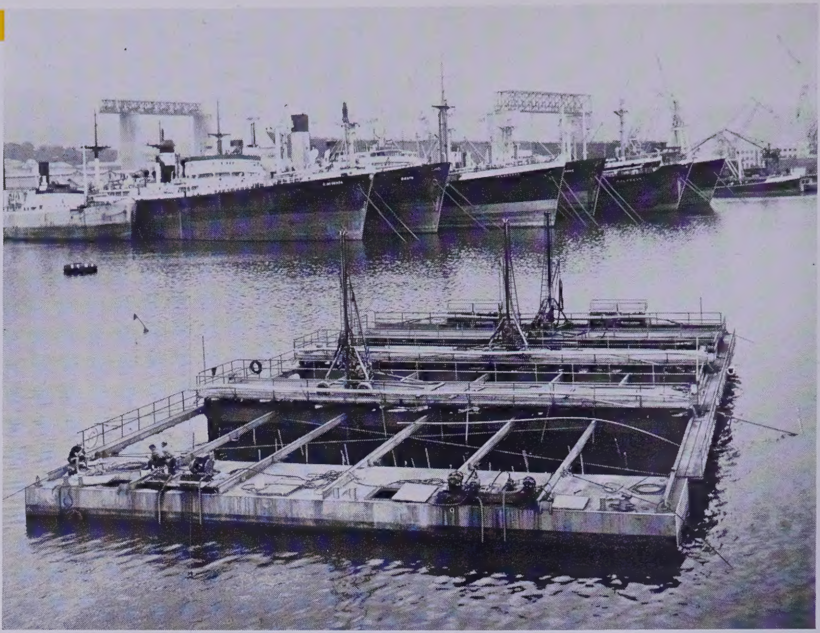
Chain feeds

Type	BMM 41-01 for 2 $^{3}/_{4}$ in. OD BMM 41-02 for 3 $^{1}/_{2}$ in. OD BMM 41-03 for 5 in. OD		BMM 42-01 for 2 $^{3}/_{4}$ in. OD BMM 42-02 for 3 $^{1}/_{2}$ in. OD BMM 42-03 for 5 in. OD	
Rod lengths permitted	4800 mm	15 ft 9 in.	4800 mm	15 ft 9 in.
Feed force	500 kg	1100 lb	1000 kg	2200 lb
Weight	485 kg	1070 lb	540 kg	1190 lb

Drill wagon

Type	BVB 33	
Winches, traction power	1000 kg	2200 lb
Lifting capacity	2000 kg	4400 lb
Weight	970 kg	2140 lb

Underwater blasting



Example: Port of Genoa, Italy

In order to accomodate 100,000-ton tankers, the port of Genoa had to be deepened. This involved removing an estimated 800,000 m³ (28,250,000 cu.ft) of sand with some rock at the bottom. When part of the sand had been removed, the contractor found that the rock was not only much harder than expected, but that the amount to be excavated was much greater – some 140,000 m³ (4,950,000 cu.ft).

The contractor set to work with conventional diesel-powered rotary drills, mounted on pontoons. Charging was carried out by divers. This method proved very slow and when the project had fallen a year behind schedule the contractor tried the OD method. After a brief trial period, five OD units were put to work, a sixth unit being held in reserve.

The result

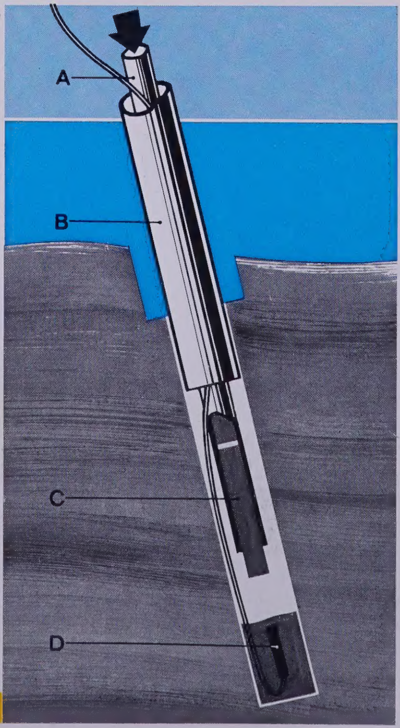
The elimination of diving operations alone represented a 40 % decrease in labour costs. Excavation performance was raised from a rate of 2–3 m³/hr (70–105 cu.ft/hr) to more than 15 m³/hr (530 cu.ft/hr).

Five times faster

An average of eight metres of rock had to be drilled and blasted to obtain the required depth. After the introduction of the OD method, drilling proceeded about five times faster than previously. Over a period of two months, working one shift per day, five 3-man crews sank 3520 holes, totalling 28,000 metres (92,000 ft).

Charging from the surface

Plastic pipes were inserted in the holes before withdrawing the drill tubes, leaving open connections to the surface. Charging was carried out from small rafts using compressed-air apparatus, thus eliminating the slow, costly diving operations.



Sketch illustrating the principles of underwater charging

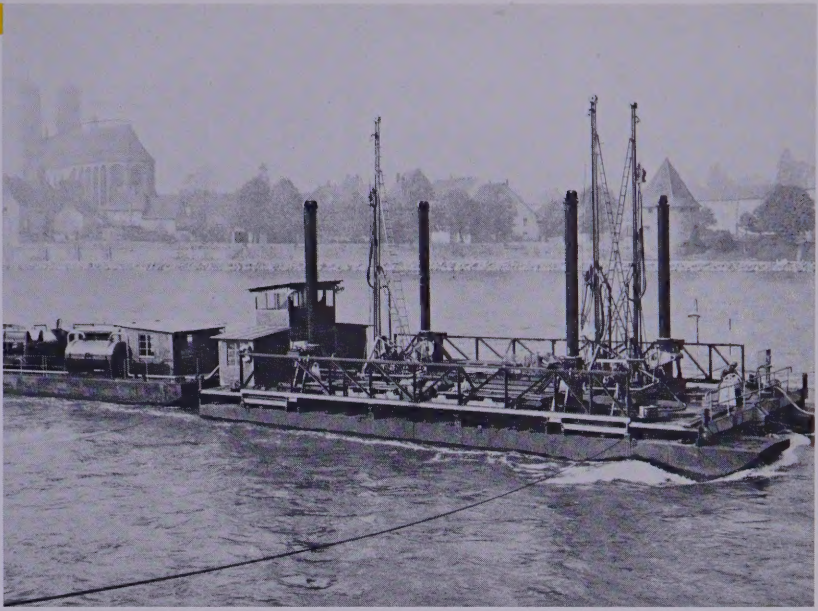
Charging is carried out through a plastic pipe using compressed-air apparatus.

A Plastic pipe for loading
B Plastic pipe replacing drill tubes
C Explosive
D Electric detonator

Example: The Rhine, Germany

During the building of a hydroelectric station on The Rhine at Stein-Säckingen in the Swiss-German border area the riverbed had to be lowered about four metres (13 ft). Blast holes had to be drilled for the excavation of a total of 800,000 m^3 (28,250,000 cu.ft) of rock, 350,000 m^3 (12,350,000 cu.ft) of gravel and some clay and silt.

The blast hole drilling was carried out with six OD units and 2 3/4 in. OD equipment. The units were on two rafts, stabilized by means of retractable legs. Average hole depth in the bedrock was 3–4.5 m (10–15 ft) and the daily excavation about 1400 m^3 (50,000 cu.ft).



Special working conditions

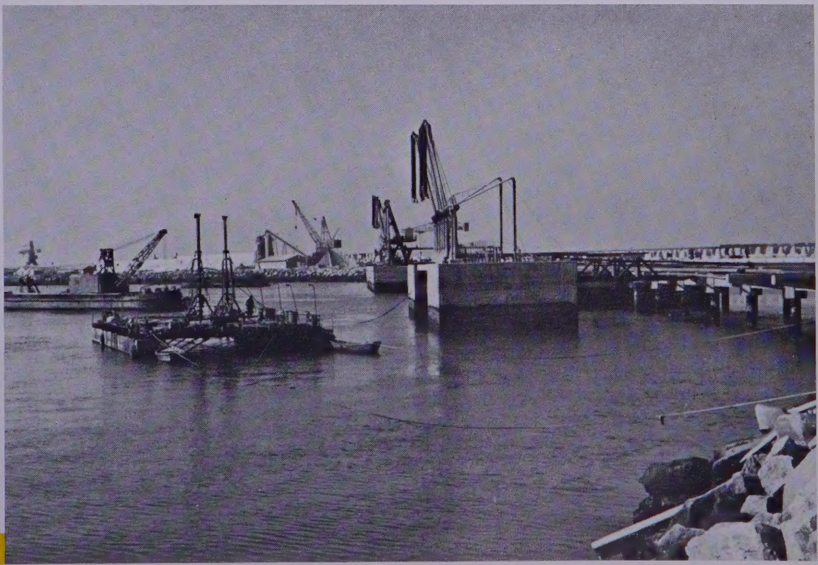
Owing to the swift river current, 2.5–3.5 m/sec (8–11.5 ft/sec), charging through plastic tubes was unsuitable. Explosives and detonators were loaded into metal pipes at the surface, then lowered down through the drill tube into the blast holes. The drill tubes were then withdrawn. Each blast used 200 kg (440 lb) of explosive, dealing with 300–400 m^3 (10,600–14,000 cu.ft) of bedrock plus any overburden.

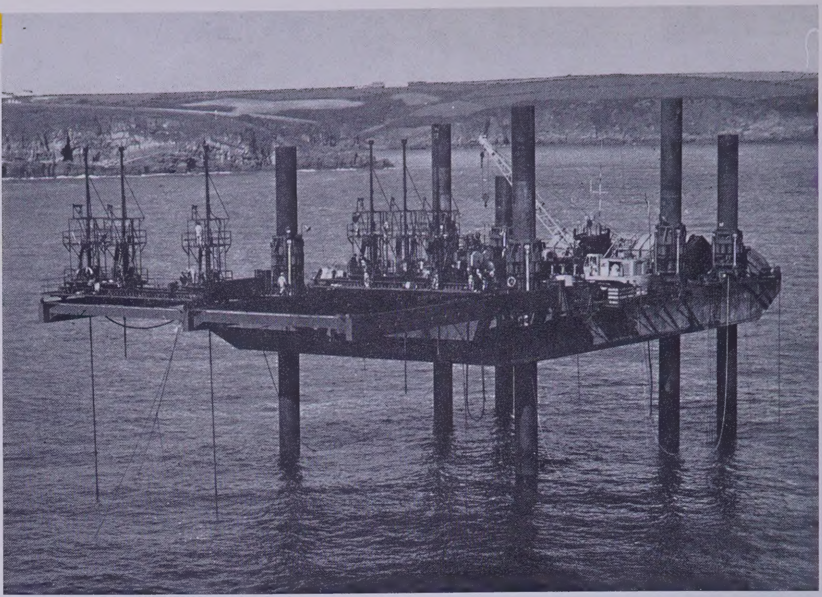
Example: Leixos Harbour, Portugal

Leixos is Portugal's largest fishing harbour – it handles 80,000 tons of fish annually and its fishing fleet comprises about 200 trawlers. The fish used to be re-loaded into small boats and then placed in baskets carried to the auction site on porters' backs. To make the work more efficient it was decided to build three piers at which the trawlers could berth.

The piers were to have an average length of 375 m (1225 ft), lying parallel to each other, 75 m (250 ft) apart. The foundations required 330 circular holes with a diameter of 2.1 m (6.9 ft) and a depth of 1 m (3.3 ft). In all more than 1,000 m^3 (35,300 cu.ft) had to be blasted and dredged.

The blast holes were drilled from platforms using two standard units and 2 3/4 in. OD equipment. 26 blast holes were drilled for each foundation hole. After drilling some 150 mm (6 in.) into the bedrock only the drill rods were used to drill a further 1.3 m (4.3 ft). Charging was then done in the usual way through a plastic tube.





Example: Milford Haven Harbour, Great Britain

One of the world's biggest harbour improvements was carried out at Milford Haven in 1969–1970.

The project was programmed in two phases. In the first, the aim was to re-align and widen the existing deep-water channel. Phase II, the final stage of the work, involves removal of some 1,700,000 m^3 (46,000,000 cu.ft) of material, of which approximately 600,000 m^3 (21,200,000 cu.ft) are rock. When the improvements are finished, Milford Haven will be able to take tankers of up to 19 metres (63 ft) draught (255,000 to 275,000 tons dwt fully laden) and to handle them at any time: larger ships will be able to use the harbour at certain tides.

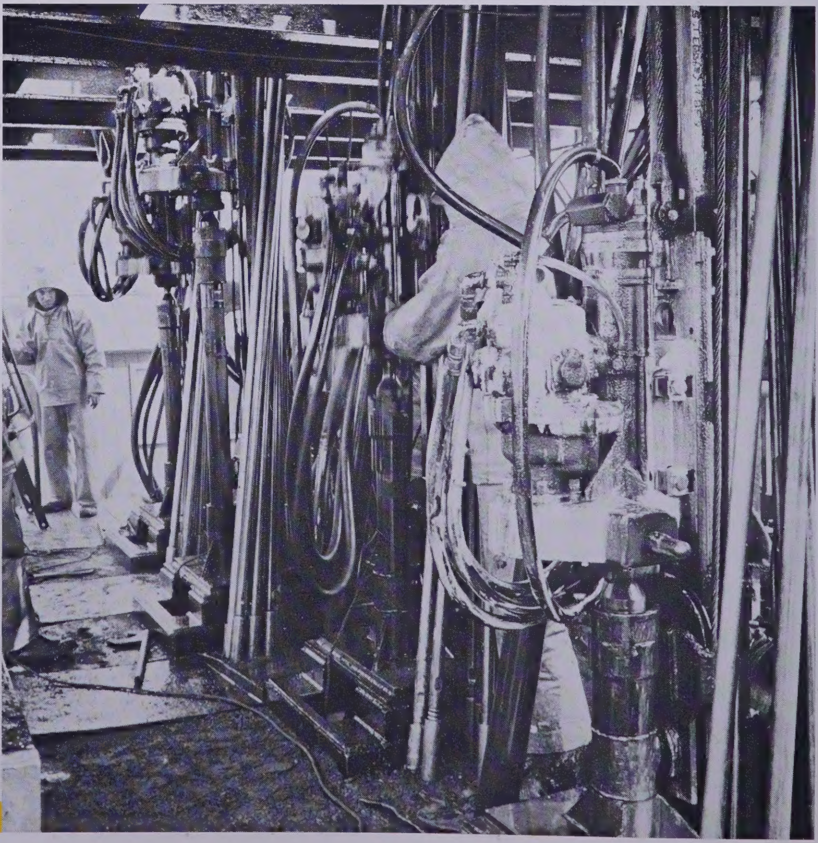
Drilling difficulties

The seabed is about 25 metres (80 ft) below the surface, depending on the tides, which vary between 6 and 8 metres (20 and 26 ft). Drilling is made even more difficult by the fact that over parts of the areas to be deepened, waves are often as much as 1.5 metres (5 ft) high. Drilling is carried out from two pontoons and one self-elevating platform. One of the pontoons carries seven, and the other six, OD rigs, and the platform carries six rigs.

The rock in the seabed is mostly red and grey sandstone, and drilling penetrates to an average depth of 4.3 metres (14 ft). However, in certain places where fissured rock occurs, penetration of up to 7.6 metres (25 ft) has taken place.

Under average conditions thirty to forty holes are drilled and charged from the pontoons in each shift. Before firing, the pontoons move approximately 100 metres (300 ft) away from the area to be blasted.

In a single installation of the platform, 240 holes can be drilled and fired.



Blasting bedrock under overburden

Example: Excavating the Lindö Canal, Sweden

The removal of 230,000 m^3 (8,125,000 cu.ft) of subsurface rock was a major problem when the Lindö Canal to Norrköping was to be built. The clay overburden was so unstable that conventional excavating methods could not be used.

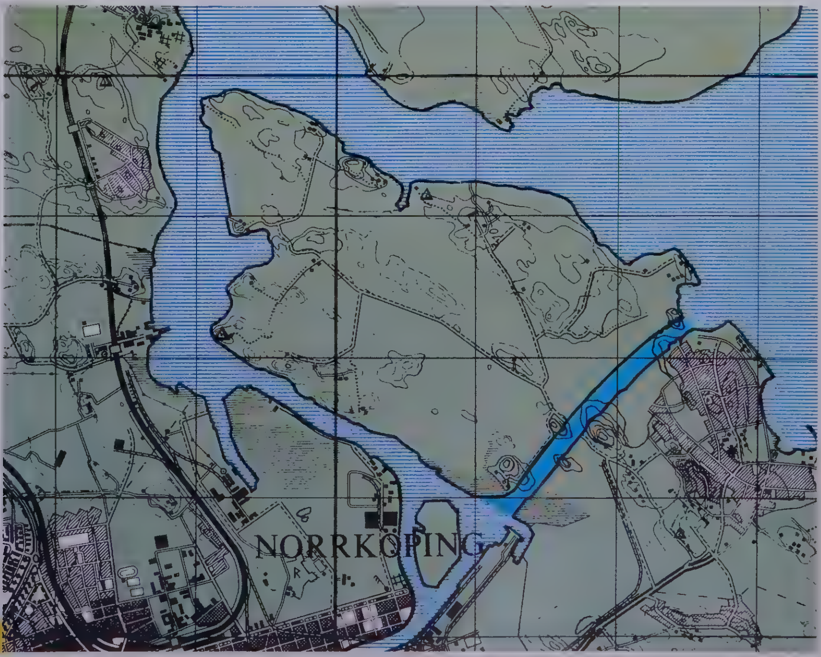
It was decided to blast the rock without removing the overburden, and to excavate entirely by dredging.

To speed up the OD drilling, special rigs with a 16 m (53 ft) feed were built. When the holes had reached their full depth the drill rods were extracted and plastic pipes inserted through the drill tube. The drill tubes were withdrawn and charging carried out through the plastic pipe, using a special compressed-air apparatus.

Fragmentation was such that broken rock could easily be handled by the dredger without any secondary blasting.

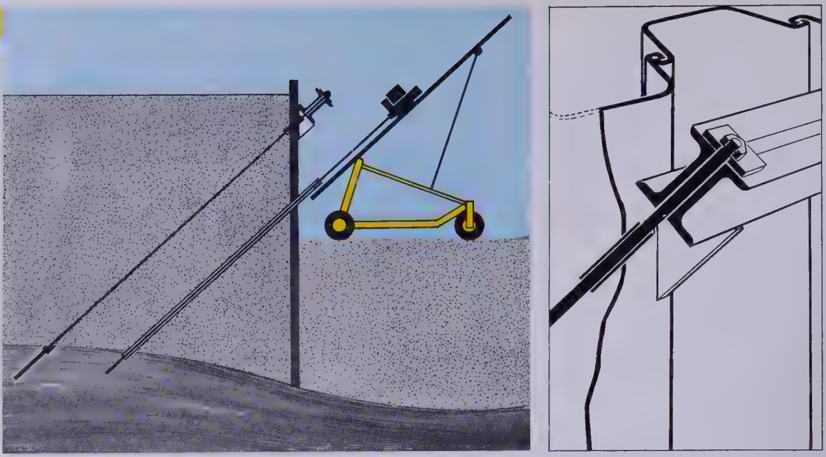
Above: The specially built drill rigs with 16 m (53 ft) feed were easily moved over the drill ore to get clear of blasting operations.

Below: The Lindö Canal is 6.4 km (4 miles) long, 70 m (230 ft) wide and 10 m (33 ft) deep. Before the canal was built, vessels had to cover an extra 16 km (10 miles) through the natural channel. Moreover, the channel was not deep enough for bigger ships.



Anchoring

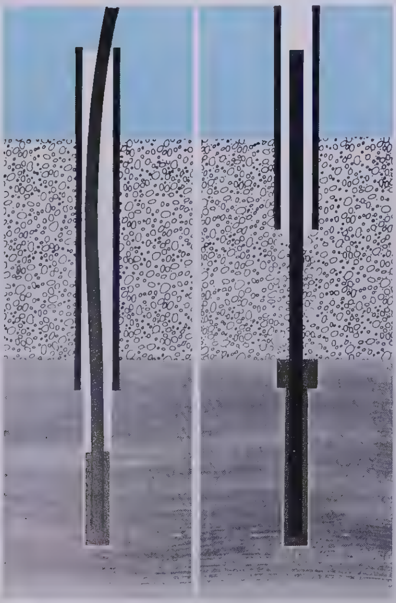
Anchors of different kinds are today to a large extent used in the building sector. They can be of either permanent or temporary nature, rock or soil anchors consisting of solid steel, cables or wires. In particular, tiebacks for securing sheet piles and supporting retaining walls of various kinds, have been very widely used. In comparison with earlier methods the anchoring reduces costs, since the worksite is free from braces and there is thus more room for the efficient use of the excavating equipment.



Installation of tieback rebars for securing sheet piles. The right picture shows the rebar fastening.

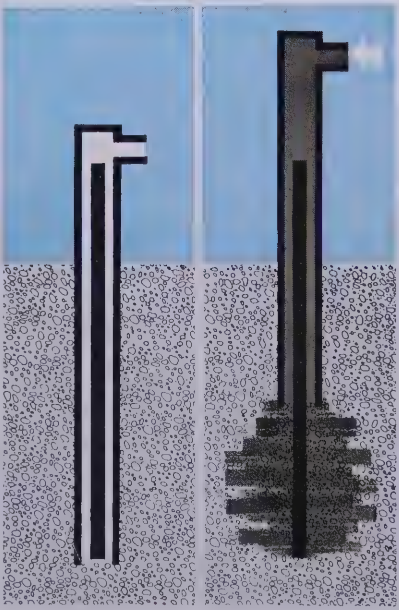
Anchoring in rock

After drilling through the overburden and some inches into the bedrock, drilling is continued with the drill rod alone, to a suitable depth for anchoring. The drill rods are withdrawn and the hole in the rock is grouted through a plastic hose. The anchor is inserted, the drill tubes are withdrawn, and the anchors can be tightened when the grout has hardened.

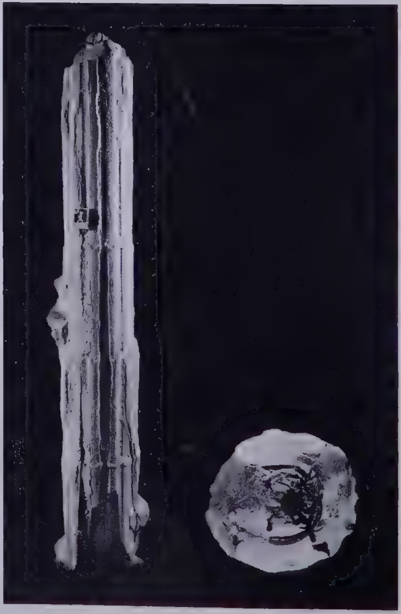


Anchoring in soil

When the suitable depth has been reached with the OD equipment, the drill rods are withdrawn. The anchor is inserted through the drill tube which is now connected to a grout pump. The grout mixture is pressed into the hole while the drill tube is withdrawn step by step, until the required anchoring zone has been injected. The rest of the drill tubes are withdrawn and the grout left to harden.



An anchorage which has been dug up. The longitudinal stripes are caused by the teeth on the drill pipe.
To the right is the anchorage, seen from the lower end. It is 250 mm (10 in) thick.

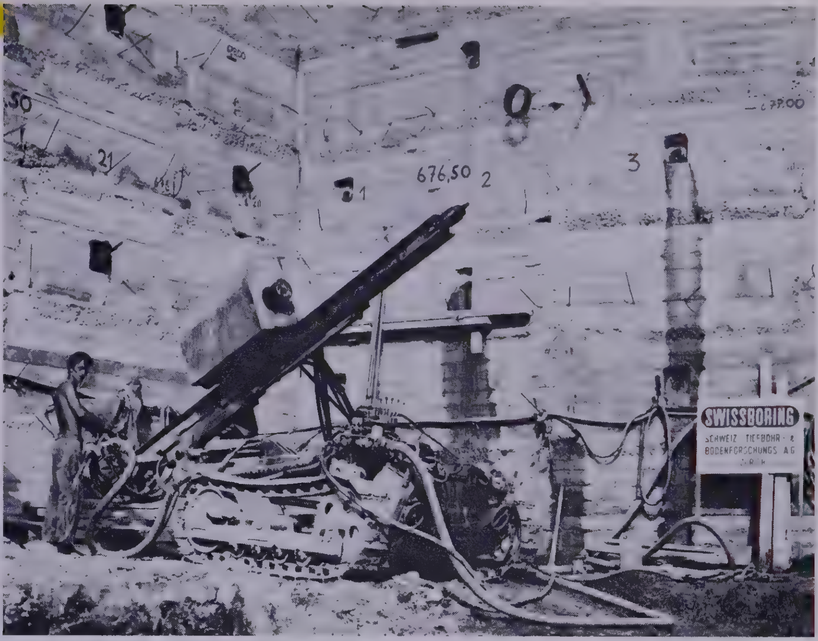


Example: Road tunnel in Zürich, Switzerland

The OD method was used for a tieback anchoring job at a road tunnel project in the centre of Zürich.

The water-table is only 3.5 m (11.5 ft) below the bottom of the concrete wall. The heavily-reinforced concrete wall was anchored with 360 anchor bolts, each having a working load of 36 tons and a length of 14 m (46 ft). Several of the anchors reached to 6 m (20 ft) below the water-table and are protected against rusting by plastic hose.

The drilling was carried out with a ROC 600 rig and 3 ½ in. OD equipment.



Example: Office and Hotel building in Sundsvall, Sweden

For a building in the centre of Sundsvall it was necessary to excavate down to 6–7.5 m (20–25 ft) below the street level and 3 m (10 ft) below the water-table. The ground consisted of fine sand and silt with a tendency to float. It was found that the best way to secure the sheet piling was to use tieback anchoring. Some of the advantages were obvious: simpler excavating, faster and simpler building and a consequent saving in time.

Ground investigation and selection of anchoring lengths

After careful investigation of the soil material and testing of anchors, it was decided to drill with 5 in. OD equipment to a depth of 16 m (53 ft), of which the effective anchoring length would be 10 m (33 ft). When the anchoring steel – with a centering device at the lower end – had been inserted inside the drill tube, the grout mixture was injected at a pressure of 10–20 kg/cm^2 (140–280 psi) and the drill tubes were withdrawn step by step, injection being continued meanwhile.

A total of 142 anchors were inserted and tightened up to give approximately 20 tons pull after the final excavating.

Grouting

Grouting is often used to seal or reinforce soil layers. This is sometimes a necessary preparatory work when building tunnels, dams, etc. The method is frequently much cheaper than either sheet piling or excavation of permeable layers with subsequent refilling using impervious materials.

Compared to conventional methods of drilling, the OD method permits considerably cheaper production of grouting holes. For example, this method has proved about ten times as fast as churn drilling in moraine deposits containing boulders.

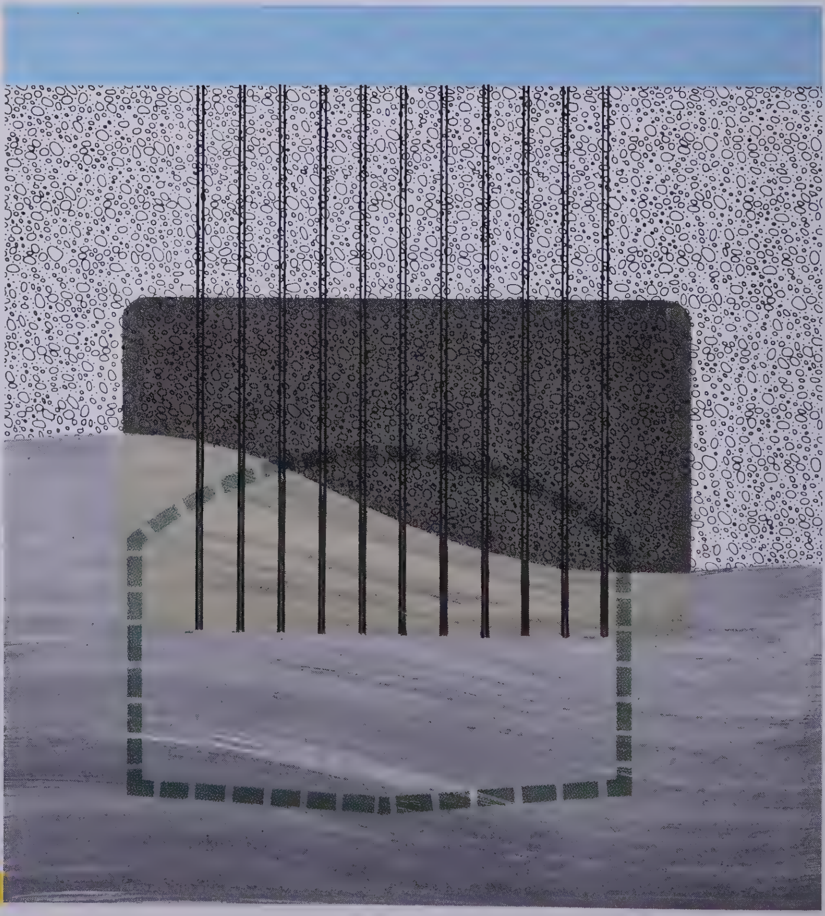
Grouting procedure

When the holes have been drilled to the required depth, the drill rods are removed and a grouting pipe inserted in the drill tube. The drill tube is extracted and, at the same time, the annular space around the grouting pipe is plugged with semiplastic mortar. High grouting pressure is applied; this cracks the mortar and forces the grout outwards through the cracks and into the surrounding soil.

Example: Tunnel excavation in Paris, France

The driving of a new tunnel for the express Metro (underground) line was carried out by the so-called shield method. The work became very difficult as the rock encountered was very unstable. The rock consisted of filling masses, sand and limestone. The contractor therefore had to reinforce the rock by grouting.

The grout holes were drilled from the surface with 3 ½ in. OD equipment. After 9 m (30 ft) depth the drilling continued, using the drill rods only, down to 25 m (82 ft). The drill rods were then extracted and a special injection tube of quite hard plastic was inserted. The drill tubes were then extracted and the drill moved to drill the next hole. Holes were spaced at approximately 2 m (6.5 ft) intervals and the grouting zone extends beyond the tunnel profile by 3–5 m (10–16 ft).

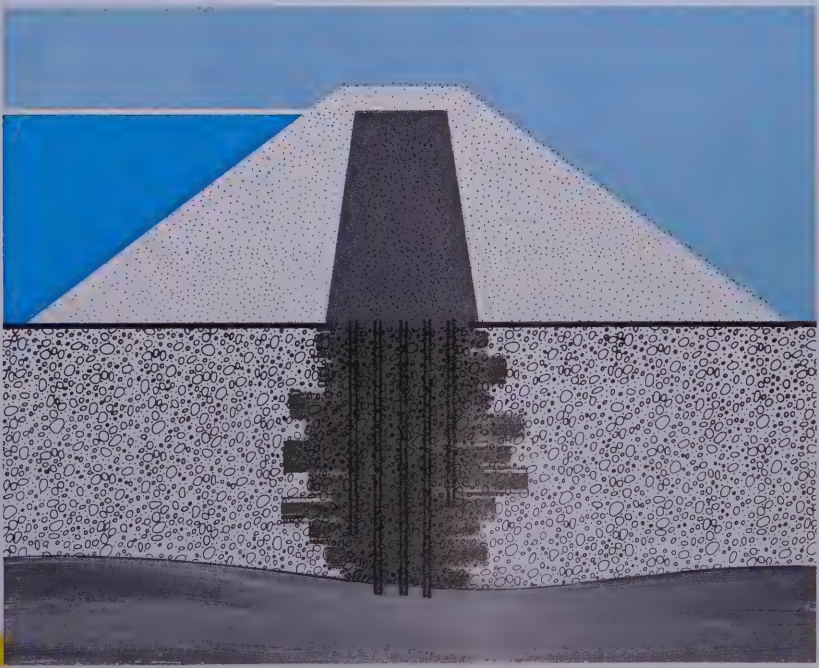


Holes were drilled through the overburden and the unstable rock. The light yellow shading shows the grouted area, and the green line indicates the tunnel profile.

Example: Sealing off dam at Kvistforsen Power Station, Sweden

Instead of excavating down to the bedrock in order to make a sealing core, it was calculated to be cheaper to form a grout curtain by using the OD method for drilling the grout holes.

Under the planned rock-fill section of the dam was a deep trench in the bedrock, filled with layers of permeable deposits. Grout holes were drilled up to 43 m (140 ft) in this material and continued for 6–24 m (20–80 ft) into the rock. Altogether, 8,500 m (27,900 ft) were drilled to form a curtain wall with a vertical area of 6,270 m^2 (67,470 sq.ft).



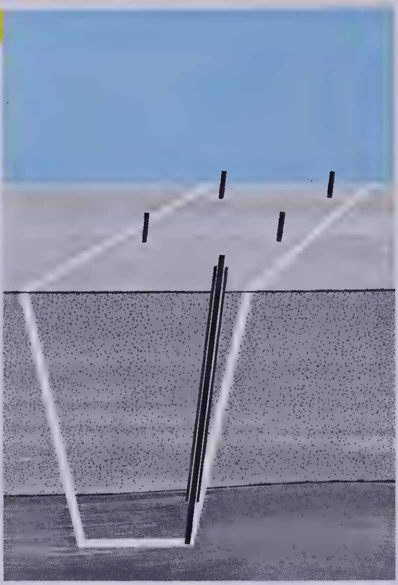
Before the dam was built up, a grout curtain was made to seal out the seepage from the overburden strata.

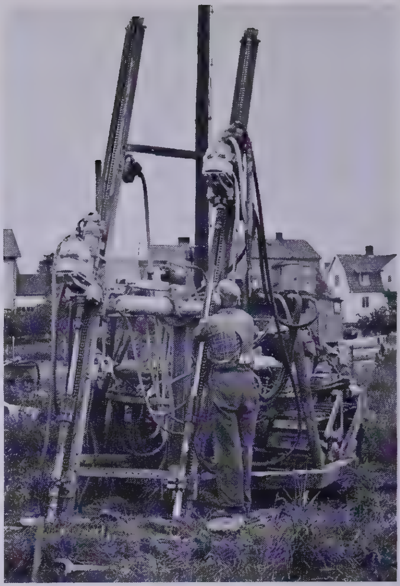
Blasting trenches

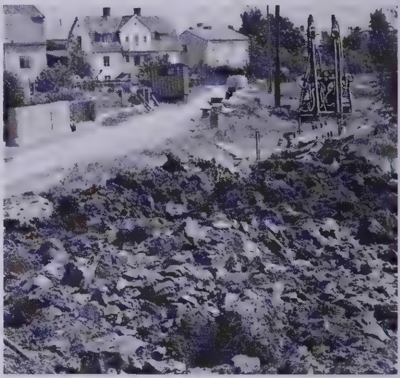
When trenches are being blasted the OD method offers the following advantages:

Overburden removal is completely eliminated. No dewatering pumps are necessary during drilling and blasting. The equipment for excavating and pipelaying can be used continuously without waiting until blasting operations have been carried out. The job can be done faster — this is particularly important in built-up areas. When blasting trenches it is often advantageous to mount the drilling equipment on a crawler tractor towing a portable compressor behind it.

Feeds are usually selected or modified to suit trench depth and so mounted that the hydraulic system of the tractor may be used for positioning. Holes are normally drilled at an angle to the longitudinal direction of the trench, to obtain optimum blasting results.







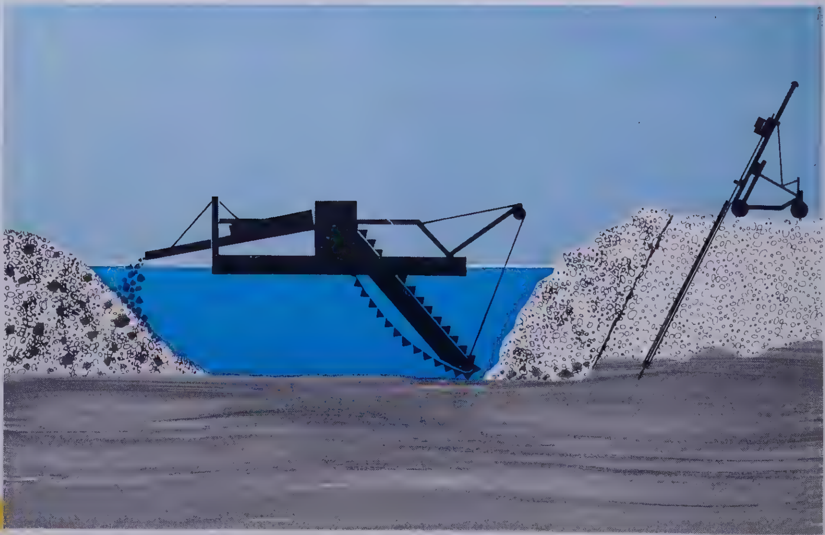
Top, left: Principle of drilling for trench blasting by the OD method. Parallel holes can be drilled into bedrock without removing the overburden.

Top, right: Two OD drills mounted on crawler.

Bottom, right: The results of blasting. Ready for excavating and pipe laying.

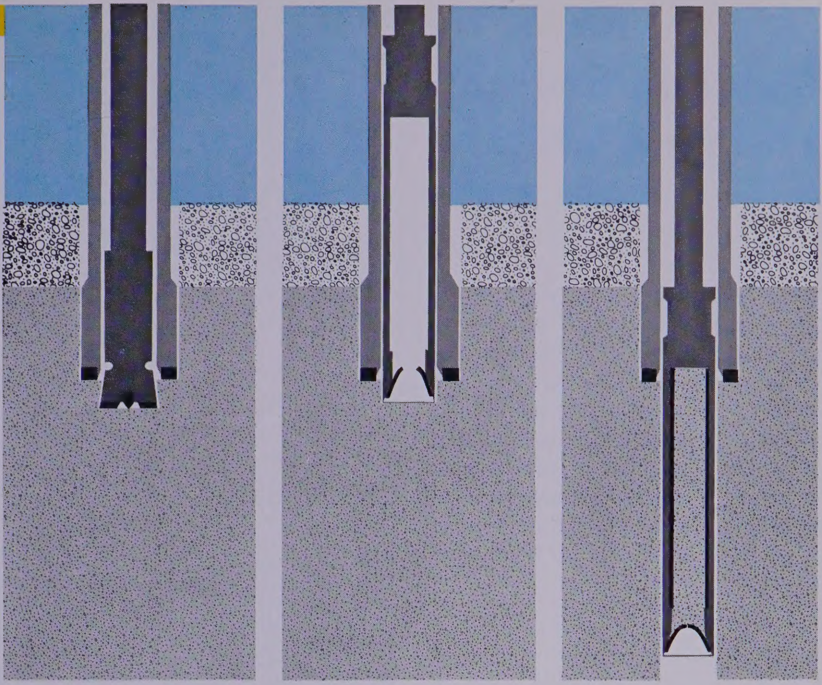
Alluvial mining

Deposits of alluvial minerals on a river or lake bed are usually dredged. With the OD method it is possible to drill and blast the tops of underwater layers of rock to ensure sufficient depth for dredgers to operate safely. Frequently the highest-grade ore is found in pockets between rock pinnacles where it is difficult to dredge. Blasting off portions of these pinnacles may make it possible to dig deeper and thus to dredge up the high-grade ore.



Subsoil and mineral exploration

The OD method allows soil samples to be taken at any stage of drilling by using the special soil-sampling equipment, or by collecting the drilling debris. It is possible to obtain useful indications of boulder sizes.
When the OD equipment has reached the bedrock, core drilling with a diamond core drill may be started to obtain the maximum information about the rock which has been drilled. Alternatively percussion drilling may be continued with the OD inner rods to the desired depth for seismic prospecting.

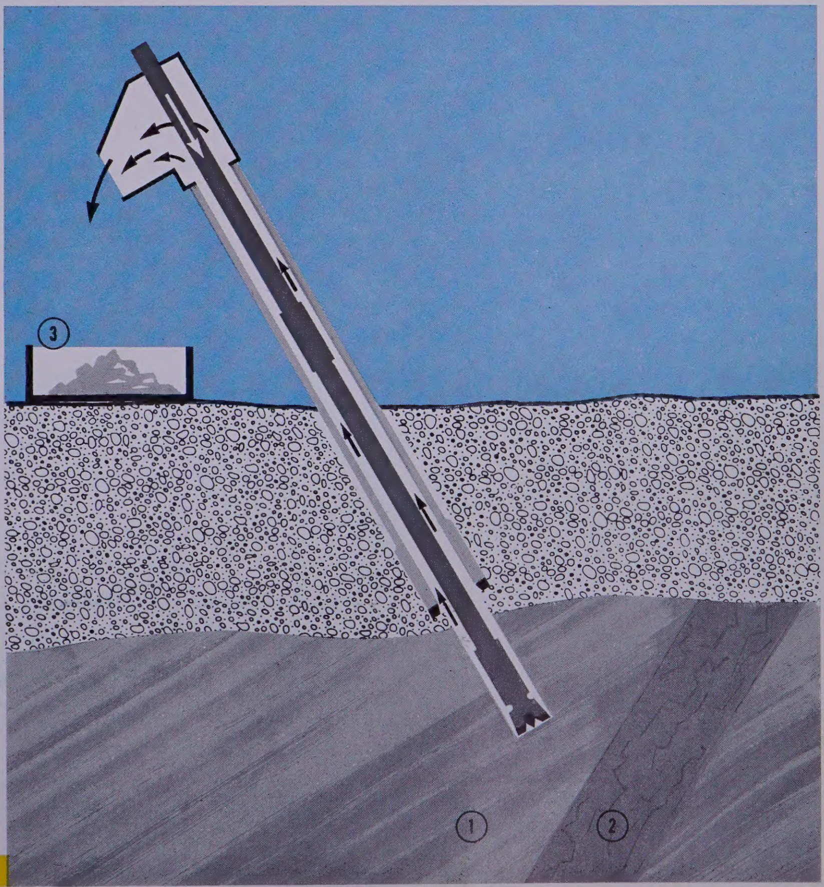


Soil sampling

After the drill-hole has reached the desired depth, the cross bit is replaced by the soil sampler, which goes down the hole attached to the drill rods.

Example: Exploration of overburden in the central Yukon, Canada

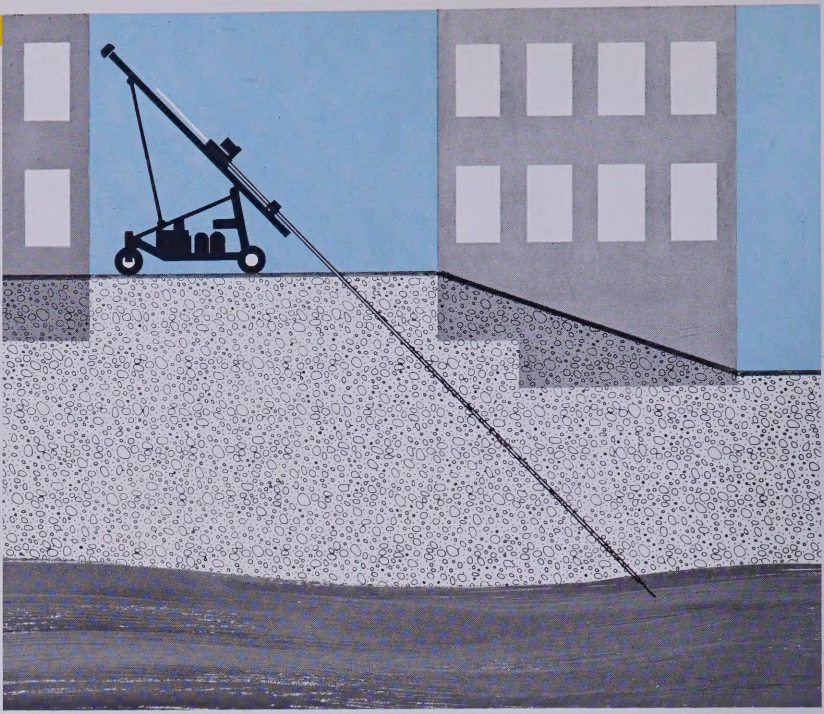
After experiments on sampling deep overburden in a known vein system, an OD rig was obtained. Following the encouriging results of the experiments, Keno Hill Mines Ltd. developed a program for exploration of other areas. Totally 91,863 m (301,389 ft) were drilled in 3954 holes from vertical up to 57 degrees inclination.
Holes were drilled dry and the cuttings airflushed into the collar of the hole where they were deflected into a catch pan. Samples were taken at 1.5 m (5 ft) intervals and are approximately 4.5 kg (10 lb) in weight. Angle holes were used to test vein systems in bedrock to a 30 m (100 ft) below surface. This method has proved fast and economical, providing close to 100 percent recovery of cuttings.



1. Bedrock 2. Vein zone 3. Catch pan

Locating bedrock, testing quality

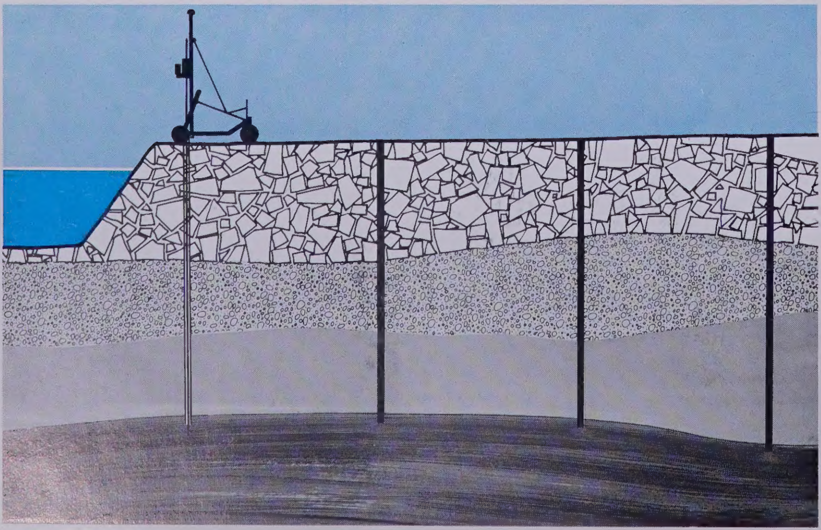
It is often necessary to investigate the location and nature of the rock by drilling holes from places subjected to heavy street traffic, for example, during the construction of the underground railways. The investigation must be completed in the shortest possible time and it may often be necessary to aim at points located underneath and inside the boundaries of buildings.



Drilling through rock fill

Drilling through rock-fill dams or rock dumps is no longer a serious problem, thanks to the OD method.

At Stockholm Free Port, holes were drilled through an average of 10.5 m (35 ft) of rock fill, 7.5 m (25 ft) of earth fill and 11.3 m (37 ft) of seabed clay down to bedrock. In the bedrock, drilling was continued for another 2 m (6–7 ft) to establish the location of bedrock for pile driving.



Date Due

JUL 15 '78			

00327

BOREAL INSTITUTE
LIBRARY

University of Alberta Library
0 1620 0335 7348

Atlas Copco

SOLD AND SERVICED BY THE WORLD-WIDE ATLAS COPCO ORGANIZATION

E 1921

Printed in Sweden Davidsons Växjö